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CR-135887

From COLLEGE OF MARINE STUDIES
UNIVERSITY OF DELAWARE
NEWARK, DELAWARE 19711

DYNAMICS OF PLANKTON POPULATIONS IN UPWELLING AREAS

(E74-10046) DYNAMICS OF PLANKTON POPULATIONS IN UPWELLING AREAS (Delaware Univ.) 12 p HC $3.00 CSCL 08A

N74-11167

Unclas
G3/13 00046

PROPOSAL NO. NAS 9 - 13344

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AUGUST 1973

INTRODUCTION

As part of our ground truth data collection program for Skylab, Philip Hass participated in a cruise aboard the Spanish research vessel, "Cornide de Saavedra" during the month of August. This cruise covered 39 stations off the coast of Northwest Africa in the Cape Blanc area from 21°20'N to 17°20'N and 22°00'W and 16°30'W. The cruise track and station positions are given in Figure 1 and Table 1 respectively. Data collected during the cruise included continuous atmospheric sampling and fluorometric monitoring of chlorophyll, along with discrete pigment analyses and collection of phytoplankton samples at all stations.

METHODS

Atmospheric Sampling:

Methods and results will be presented in a later report.

Continuous Chlorophyll:

Chlorophyll a at the 3 m depth was monitored continuously throughout the cruise using a Turner 111 fluorometer converted to 50 cycle operation and installed with a red sensitive (R136) phototube for enhanced sensitivity. A Leeds and Northrup strip chart recorder in conjunction recorded the output. The system was calibrated using the discrete sample analysis for chlorophyll a described below. Typical traces obtained for the upwelling and open ocean are shown in Figure 4.

Pigment Analysis:

Five liters of sea water were taken with Niskin bottles at 0, 10, 20 and 50 m depths for each station. The sample was filtered through a Whatman GF/c 4.25 cm filter using Bernoulli suction, placed in a screw-cap test tube along with 6 milliliters of 90% acetone, and subsequently held in the dark below 0°C for 24 hours. The sample was allowed to warm up, then centrifuged at 3500 rpm for 20 minutes in a Hettich Universal II.

The absorbance of the extracted pigments was read at 750, 665, and 430 nanometers using a Beckman DU-2. Equations used for calculating chlorophyll a and Margalef's pigment ratio are given below.

$$\text{Chlorophyll a } \left(\text{Micrograms/meter}^3\right) = 12.6 \cdot (D665-D750)\cdot(V/(P\cdot VOL))$$

$$\text{Margalef's Pigment Ratio} = \frac{D430 - (F \cdot D750)}{D665 - D750}$$

D750, D665, D430 - optical density at specified wavelengths
V - acetone extraction volume in milliliters
P - path length of cuvette in centimeters
VOL - sample volume in liters
F = 4.0, turbidity correction factor at 430 nm
(Strickland and Parsons, 1972)

Margalef's pigment ratio is an index used to assess photosynethic pigment diversity and can indicate community structure as well as primary production of phytoplankton populations.

Values for chlorophyll a and Margalef's pigment ratio are given in Tables 2 and 3 respectively. Contour plots drawn for the surface values are found in Figures 2 and 3 showing their horizontal distribution in the study area.

Phytoplankton Samples:

123 ml. of whole seawater was preserved in 2 ml. of Lugol's solution in brown glass bottles. The samples were settled for 30 hours, followed by concentration to 40 ml. and shipped to Delaware for microscopic examination.

Hydrographic Data:

Standard hydrographic casts for temperature, salinity and nutrients were made as well as secchi disk measurements. These data will be supplied to us by the Spanish Oceanographic Institution upon completion of their data reduction.

Preliminary Results

1. The measurements of chlorophyll a concentration along with the

continuous fluorometry traces (as well as the temperature data, to be supplied to us by the Spanish) provide us with a relatively intense ground truth data collection for correlation with the Skylab imagery (Fig. 2).

2. A strong upwelling zone was located off Cape Blanc associated with high chlorophyll values and a low pigment ratio, clearly an area of intense organic production. See Figures 2 and 3.

3. Chlorophyll a concentrations exhibited a considerable range, from 5.59 mg/m^3 at station F32 to 0.11 mg/m^3 recorded at station E1 and others (Table 2).

4. The continuous monitoring of chlorophyll revealed classical heterogeneity and high chlorophyll values for upwelling areas as well as the relative homogeneity and low chlorophyll values for open ocean systems (Fig. 4).

5. Upon examination of the phytoplankton samples and accumulation of the nutrient and hydrographic data, multivariate statistical analysis will be performed to determine associations of the phytoplankton populations with the nutrient and hydrographic environment.

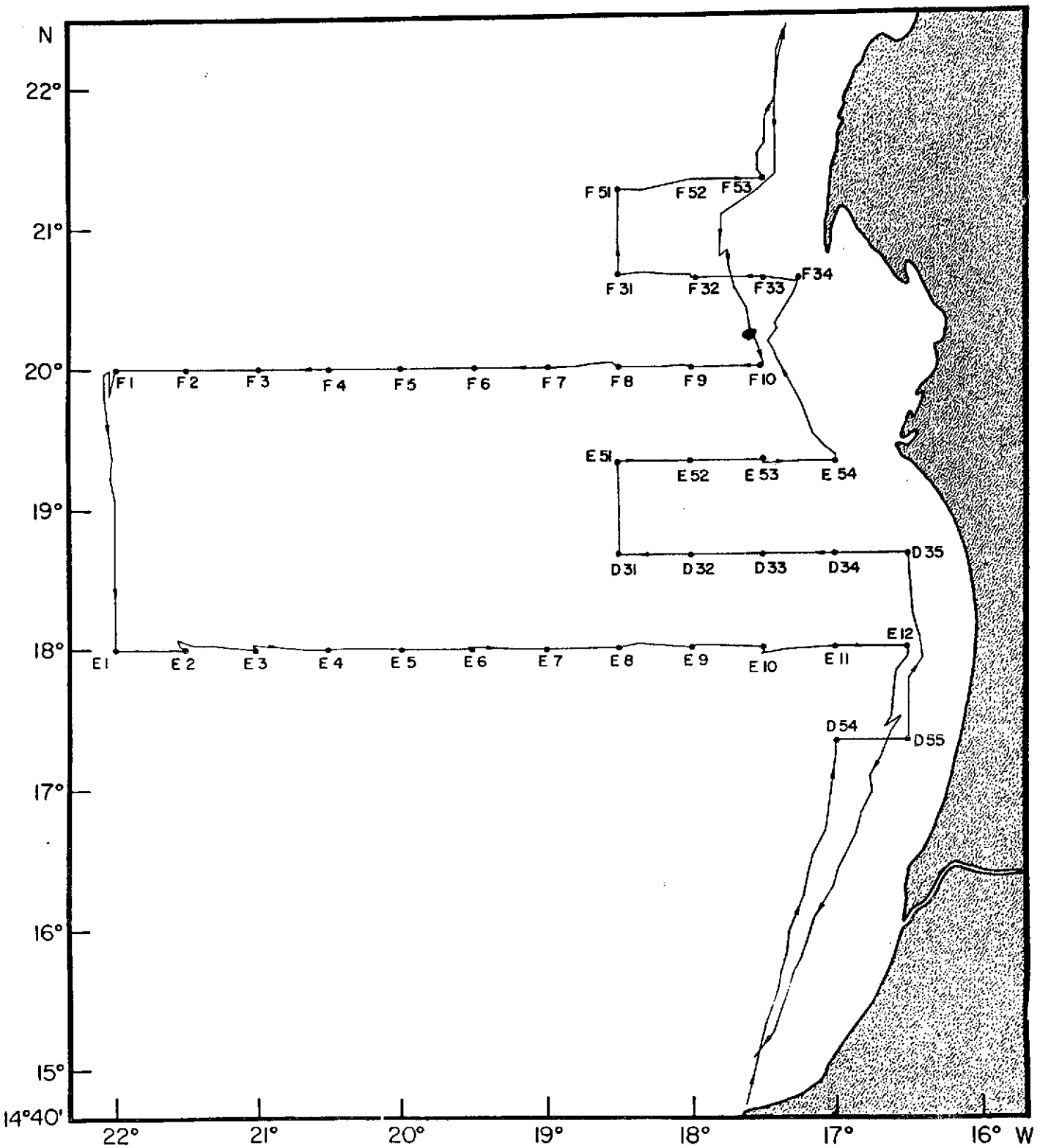


Fig. 1

Cruise Track

Fig. 2

Surface Chlorophyll

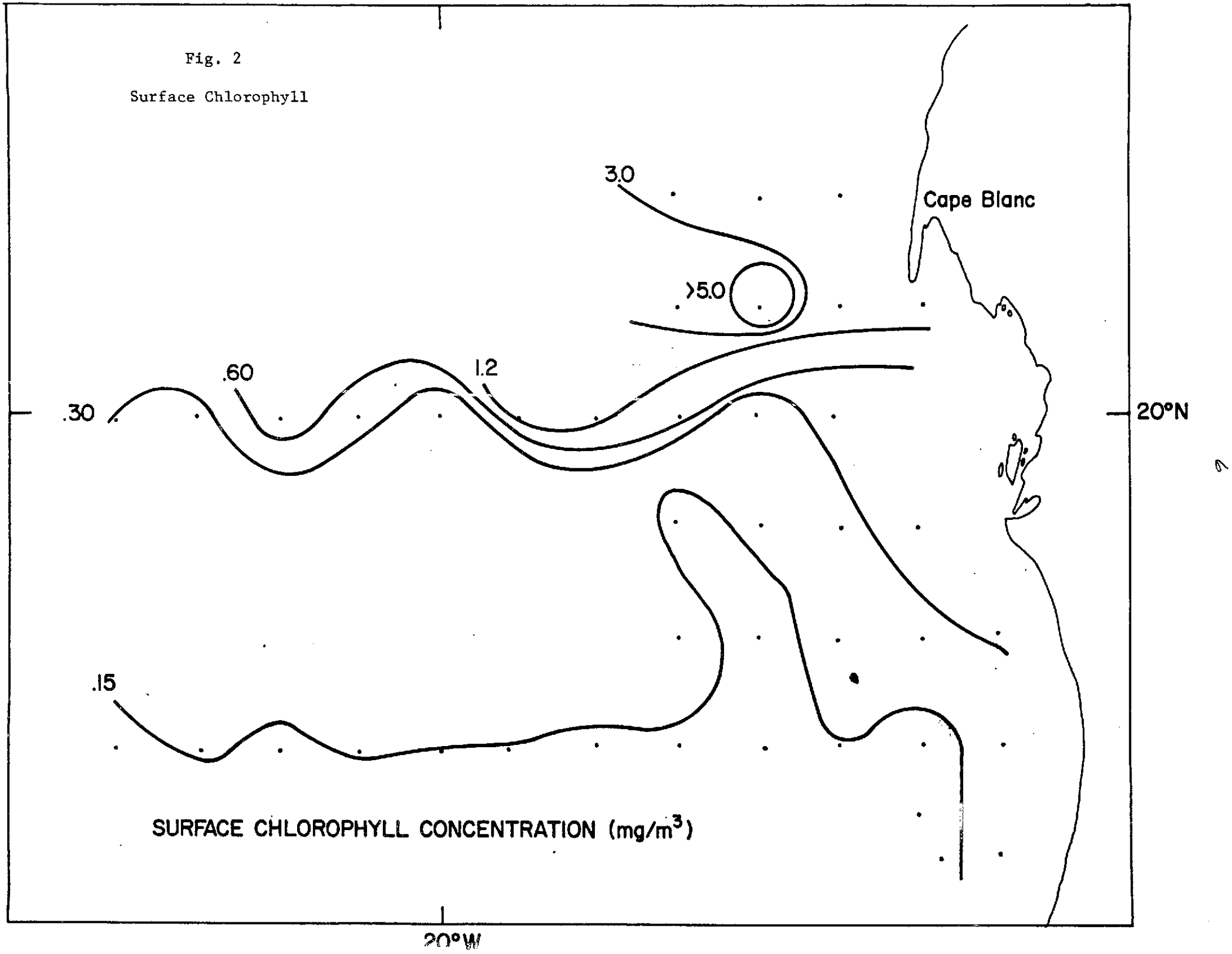
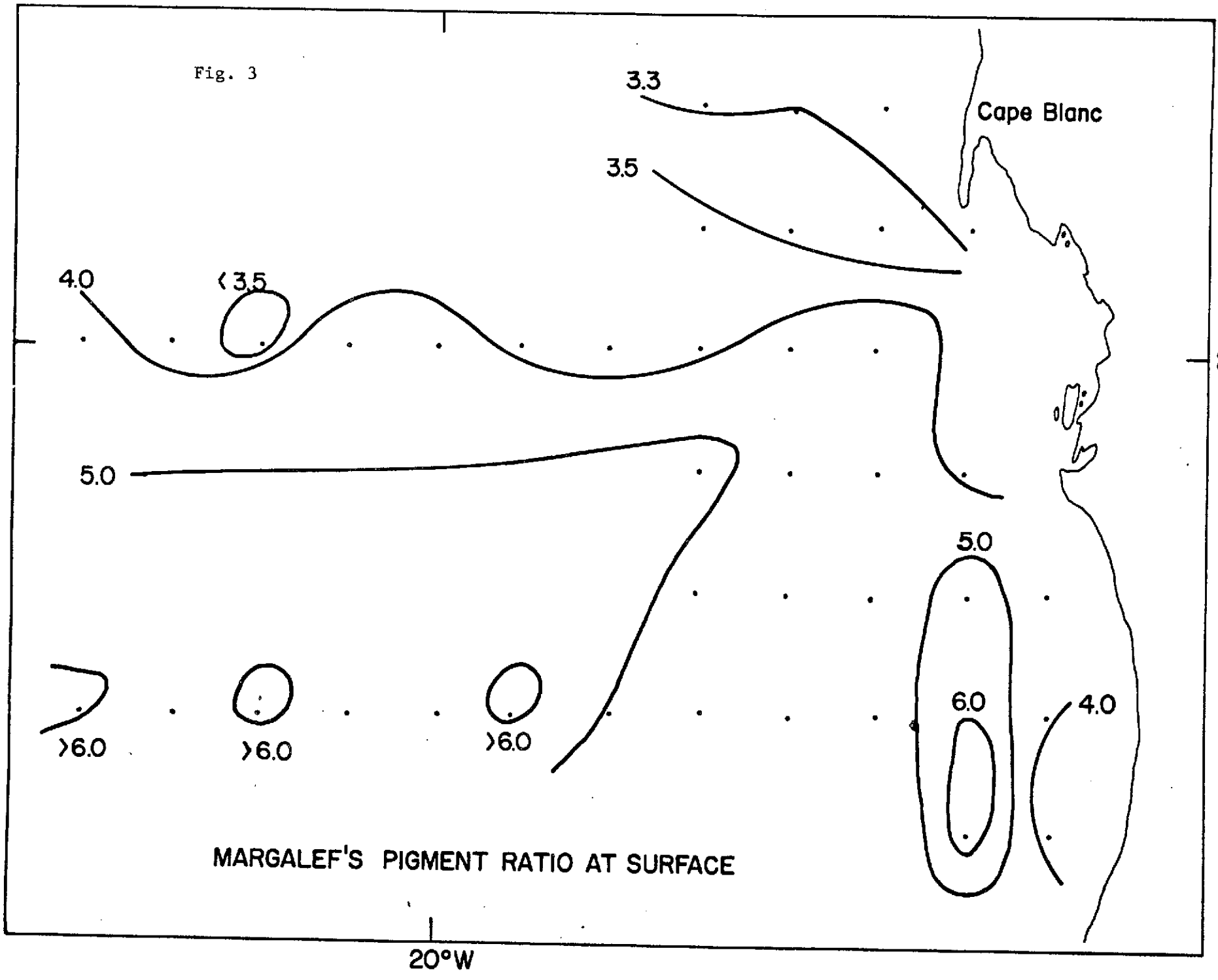


Fig. 3


3.3
Cape Blanc
3.5
4.0
< 3.5
20° N
5.0
5.0
6.0
4.0
> 6.0
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MARGALEF'S PIGMENT RATIO AT SURFACE
20° W

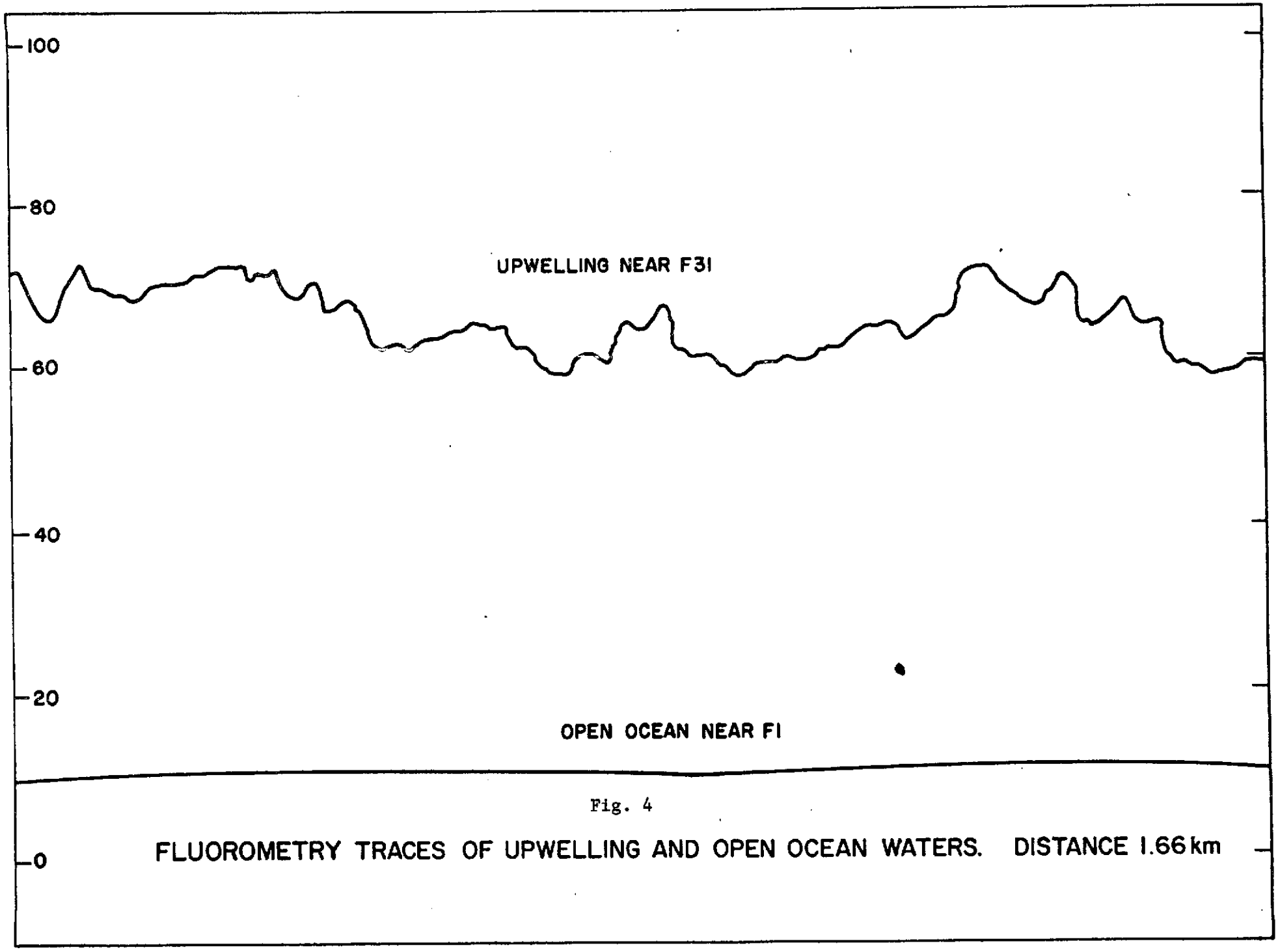

Fig. 4

FLUOROMETRY TRACES OF UPWELLING AND OPEN OCEAN WATERS. DISTANCE 1.66 km

TABLE 1

Coordinates of Station Positions

Station	Latitude N	Longitude W
F53	21°20'	17°30'
F52	21°20'	18°00'
F51	21°16'	18°30'
F34	20°38'	17°16'
F33	20°38'	17°30'
F32	20°38'	17°59'
F31	20°39'	18°30'
F10	20°00'	17°30'
F9	20°00'	18°00'
F8	20°00'	18°30'
F7	20°00'	18°59'
F6	20°00'	19°30'
F5	20°00'	20°00'
F4	20°00'	20°31'
F3	20°00'	21°00'
F2	20°00'	21°30'
F1	20°00'	22°00'
E54	19°20'	17°00'
E53	19°20'	17°30'
E52	19°20'	18°00'
E51	19°20'	18°31'
E35	18°40'	16°30'
E34	18°40'	17°00'
E33	18°40'	17°30'
E32	18°40'	18°00'
E31	18°40'	18°30'
E12	18°00'	16°30'
E11	18°00'	17°00'
E10	17°58'	17°30'
E9	18°00'	18°00'
E8	18°00'	18°30'
E7	18°00'	19°00'
E6	18°00'	19°30'
E5	18°00'	20°00'
E4	18°00'	20°30'
E3	18°00'	21°00'
E2	18°00'	21°30'
E1	18°00'	22°00'
D55	17°20'	16°30'
D54	17°20'	17°00'

TABLE 2

Chlorophyll Concentration in Milligrams/Meter^3

Station	Depth (meters) 0	10	20	50
F53	1.44	1.53	1.63	0.95
F52	1.21	1.26	1.36	1.01
F51	2.91	2.68	2.49	0.38
F34	1.81	1.75	1.66	0.62
F33	2.42	2.28	2.31	0.59
F32	5.29	5.07	5.59	2.08
F31	3.21	3.18	3.10	1.18
F10	0.33	0.32	0.29	0.18
F9	0.27	0.20	0.98	0.17
F8	0.74	0.73	0.67	0.59
F7	1.29	1.25	1.44	0.23
F6	1.92	1.98	2.21	0.36
F5	0.24	0.27	0.17	0.42
F4	0.38	0.38	0.42	0.41
F3	0.74	0.82	0.76	0.41
F2	0.27	0.39	0.30	0.18
F1	0.30	0.26	0.24	0.69
E54	0.47	0.42	0.45	0.79
E53	0.24	0.18	0.27	0.65
E52	0.23	0.13	0.15	1.82
E51	0.12	0.15	0.42	0.14
E35	0.56	1.06	1.35	2.84
E34	0.24	0.20	0.17	1.10
E33	0.17	0.11	0.11	1.24
E32	0.12	0.15	0.15	0.36
E31	0.23	0.21	0.30	0.33
E12	0.23	0.21	0.23	0.26
E11	0.11	0.06	0.20	0.45
E10	0.15	0.18	0.44	0.30
E9	0.12	0.15	0.23	0.39
E8	0.15	0.09	0.17	0.14
E7	0.12	0.11	0.17	0.27
E6	0.15	0.20	0.17	0.20
E5	0.15	0.11	0.29	0.12
E4	0.18	0.18	0.23	0.53
E3	0.12	0.12	0.17	0.30
E2	0.20	0.18	0.21	0.60
E1	0.11	0.12	0.14	0.30
D55	0.29	0.26	0.65	0.41
D54	0.14	0.11	0.11	1.16

TABLE 3

Margalef's Pigment Ratio

Station	Depth (Meters) 0	10	20	50
F53	3.19	3.12	3.04	2.92
F52	3.31	2.98	2.93	3.33
F51	3.25	3.07	3.26	4.50
F34	3.05	2.94	3.09	4.15
F33	3.43	3.34	3.45	3.95
F32	3.37	3.30	2.49	4.42
F31	3.52	3.44	3.60	3.90
F10	4.68	3.95	4.63	4.67
F9	4.44	4.08	4.11	4.27
F8	3.88	3.94	3.77	4.36
F7	3.82	3.77	3.85	5.33
F6	3.84	3.70	3.59	4.21
F5	4.19	3.11	4.91	3.39
F4	4.36	3.76	5.14	17.48
F3	3.27	3.09	3.22	4.67
F2	3.94	3.19	3.75	6.00
F1	4.40	3.82	3.81	4.32
E54	3.90	3.93	3.87	3.85
E53	4.25	3.75	3.33	4.40
E52	4.60	4.80	4.33	4.01
E51	5.50	4.50	4.10	6.33
E35	4.11	3.80	3.42	3.43
E34	5.38	4.62	90.27	27.51
E33	4.00	4.00	2.71	4.30
E32	4.87	2.30	3.30	4.67
E31	4.20	3.43	3.30	5.09
E12	4.00	2.79	4.27	4.59
E11	6.00	4.50	4.77	4.70
E10	4.80	2.75	4.48	5.20
E9	4.88	2.90	4.40	4.96
E8	4.20	3.17	5.00	6.89
E7	5.00	4.57	5.55	4.94
E6	6.70	4.23	5.36	5.23
E5	5.40	5.71	4.58	7.00
E4	5.25	1.83	6.27	4.71
E3	6.63	5.25	4.73	4.70
E2	5.46	3.92	4.36	5.63
E1	8.57	6.13	5.56	5.80
D55	3.84	3.18	3.49	3.96
D54	7.44	4.71	5.86	4.39